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Growth of the garden dormouse (*Eliomys quercinus* Linnaeus, 1766) in southwestern Spain

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Abstract

Studied the growth of young dormice *(Eliomys quercinus lusitanicus)* from the SW of the Iberian Peninsula and compared with that of juveniles from Germany and El Pardo (Central Spain). Body measurements and weights were taken from suckling animals in captivity, and juveniles in the field (n = 57) and from scientific collections (n = 23). The mean daily growth, the average growth rate, and the mean percentage of adult size attained at different ages were calculated. The results show that, generally, the growth pattern is similar in the three populations studied. However, growth takes longer in the dormice from SW Spain which reach a greater size.

Introduction

Geographical variation in the body size of garden dormice (Rodentia, Gliridae) is very high. The average weight of adults ranges from less than 60 g in Central Europe (Kahmann and Staudenmayer 1969) to more than 170 g on Formentera Island, Spain (Kahmann 1970; Kahmann and Lau 1972).

In Europe, studies on garden dormouse growth have been conducted in Bavaria and Hessen, Germany (Kahmann and Staudenmayer 1969, 1970), in the French Alpes (Le Louarn and Spitz 1974), and in El Pardo, Central Spain (Palacios 1974). An analysis of growth in *quercinus* subspecies has been conducted by *Kahmann* and *Thoms* (1977).

In this paper the development and growth of *Eliomys quercinus lusitanicus,* one of the larger subspecies of garden dormouse (Petter 1961), is studied and compared with the available data on *Eliomys quercinus quercinus* in Bavaria and Hessen (Germany) and in El Pardo (Central Spain).

Material and methods

The garden dormice used for this study come from the SW of the Iberian Peninsula, from Doñana National Park (Huelva province) (37° N 0′, 6° 2 ′W) to Medina-Sidonia (Cádiz province) (36°, 30 ′N, 5° 35 ′W).

To study the development of the youngs from birth to weaning, 8 sucklings, born in captivity from a female captured in the field, were measured and weighted at 4–6 day intervals. For post-weaning growth studies, data from 57 juvenile individuals were obtained using a capture-mark-recapture technique twice a month during three consecutive years (1978–1981). Young specimens (Moreno 1984) from the Doñana Biological Station (CSIC) collection (n = 23) were also examined.

Standard body measurements were taken for each animal: head and body length (HBL), tail length (TL), ear length (EL), hindfoot length (HL) and weight (W). Weight of captured individuals were fitted to a Von Bertalanffy curve using Ricklefs' graphical method (1967). Ages for the individuals captured in the field were estimated when first captured by interpolation of their weight on a Gompertz curve fitted to the weights of the captive litter by Ricklefs' graphical method.

The growth rate has been expressed in three ways:

1. Average daily increase (I) in absolute values during a determined period of time:

$$I = (X_2 - X_1)/(t_2 - t_1)$$

where X_2 and X_1 are the means of each measurement at times t_2 and t_1, respectively (being t_2 the end of the period considered and t_1 the beginning).

2. Average daily growth-rate (R) according to the formula used by Gurnell and Rennoll (1983):

$$R = (\ln X_2 - \ln X_1)/(t_2 - t_1)$$

This both indexes, I and R, allow comparison of growth rates independently of the frequency in which measurements are taken.

3. The proportion (P) with respect to adult size:

$$P = X_1/X$$

were X_1 is the measurement obtained at a certain time and X is the mean of the same measurement in adult specimens, obtained from Kahmann and Staudenmayer (1969) for *quercinus* in Germany, from Palacios (1974) for *quercinus* in El Pardo and from Moreno (1984) for *lusitanicus*.

Results

Growth during lactation

At birth, the average weight of the laboratory litter specimens was 2.0 g, which is slightly under 2.32 g reported by Palacios (1974) in El Pardo and the 2.52 g and 2.45 g observed by Kahmann and Thoms (1977) in Bavaria. The young were hairless, the eyes and auditory meatus were closed and the ears flattened against the head. On day 11, the ears were detached, the pelage appeared as distinct facial mask and dorsal fur was also beginning to appear. On day 17, the mask and tail markings were clearly defined, the dorsal fur growth was evident and signs of abdominal fur could be noticed. By day 21 the eyes and auditory meatus were open. One of the young showed aggressive behaviour. On day 36, the face, body and tail fur was almost completely grown, the animals were nutritionally independent and their aggressiveness was increasing.

Leaving aside the inaccuracy arising from taking measurements weekly, this pattern of development roughly coincides with that of other European populations of the species (Valentin 1980).

Table 1 shows measurement change during the first month of life. Table 2 shows the average daily increase (I), the average daily growth-rate (R) from day 11 to day 30 and the percentage of adult size (P) reached by day 30 in our population and those of Germany and Central Spain.

The greatest mean daily increase was observed in TL and the greatest mean daily growth-rate was observed in W. However, considering the proportion with respect to the

Table 1. **Body measurements (averages [X] and range [r]; weight [W], head-body length [HBL], tail length [TL], ear length [EL] and hind foot length [HL]) of eight captive suckling dormice *(Eliomys quercinus lusitanicus)* from SW Spain at different ages**

Age (days)		W	HBL	TL	EL	HL
11	X	6.3	53.1	29.7	6.6	10.9
	r	5.1–6.8	50.3–56.5	27.4–31.6	5.7–7.0	10.5–11.5
17	X	9.1	57.5	37.4	9.0	14.6
	r	8.5–10.5	54.3–60.0	35.5–40.0	8.4–9.7	13.9–15.5
21	X	11.4	67.7	45.9	10.5	17.2
	r	10.5–14.0	62.2–72.8	44.3–48.8	9.0–12.0	16.0–18.0
25	X	13.1	66.1	51.3	11.4	20.2
	r	12.3–15.5	62.2–73.0	47.9–58.0	9.2–13.1	17.3–18.9
29	X	14.4	70.3	59.3	13.7	20.9
	r	13.0–18.0	68.0–72.4	56.8–63.6	12.7–16.2	19.3–22.3

Table 2. Average daily increase (I), average growth-rate (R), and mean percentage of adult size (P) of weight (W), head-body length (HBL), tail length (TL), ear length (EL) and hind foot length (HL) of suckling dormice *(Eliomys quercinus)*

	I			R			P		
	SWS	CS	G	SWS	CS	G	SWS	CS	G
W	0.45	0.33	0.77	0.046	0.044	0.057	11	22	41
HBL	0.96	1.15	1.43	0.015	0.017	0.023	47	–	–
TL	1.64	1.70	1.56	0.036	0.029	0.046	50	–	–
EL	0.39	0.45	–	0.038	–	–	54	–	–
HL	0.55	0.37	0.48	0.034	0.031	0.032	71	–	–

Data for the SW of the Iberian Peninsula (SWS) come from the present work and Moreno (1984). Data for Central Spain (CS) are taken from Palacios (1974) and for Germany (G) from Kahmann and Staudenmayer (1969).

adult size, it is HL the parameter that most closely approaches the adult value and W the least. The weight gain fits a Gompertz curve with an asymptote of 100.3 g and a growth rate of 0.02879.

Growth after warning

The mean weight of the youngest individuals captured in the field was 20 g. The weight gains of a specimen captured in 9 consecutive trapping periods fit a Von Bertalanffy curve with an asymptote of 82 g. The mean growth-rate for all the individuals, considering this asymptote, is 0.00797, which results in a growth curve expressed by the equation:

$$W = 82 \times (1 - \frac{e^{-0.0179\ (t-39)}}{3})^3$$

according to Ricklefs's method, which would be representative of the growth in our population of garden dormice.

For the period between 28 and 70–80 days old, the average daily increases, the average daily growth-rate and the proportion with respect to adult size of W, HBL and HL are presented in Table 3. Weight has the lowest rate of change, reaching only 55.54 % of its definitive value when 70–80 days old. HL, reaches adult size when 80 days old, having a high percentage of adult size when 30 days old. HBL achieves from 80 % to 90 % of its definitive value when 70–80 days old.

In Figure 1, the proportion reached with respect to adult size in terms of HBL and W

Table 3. Average daily increase (I), average daily growth-rate (R), and mean percentage of adult size (P) of the weight (W), head-body length (HBL) and hind foot length (HL) in *Eliomys quercinus lusitanicus* between 29 to 70–80 days old

Method	Age (days)	W	HBL	HL
(I)	29–80	0.74	0.40	0.03
(R)	29–80	0.023	0.009	0.003
(P)	29–80	19	55	86
(P)	40–50	31	69	92
(P)	50–60	38	73	64
(P)	60–70	50	–	–
(P)	70–80	56	82	97

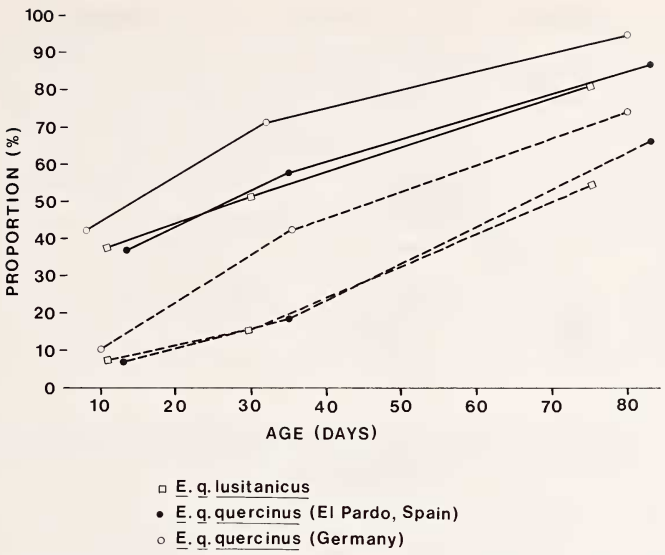

Fig. 1. Comparison of the relative growth (mean proportion of adult size) of the head-body length (continuous line) and weight (broken line) of the *lusitanicus* and *quercinus* (Central Spain and Germany) dormice subspecies. The data from Germany and Central Spain were obtained from Kahmann and Staudenmayer (1969) and Palacios (1974) respectively

for *Eliomys quercinus lusitanicus* is compared with *Eliomys quercinus quercinus* from Bavaria and Central Spain. Three facts can be noticed: 1. The two Spanish populations are similar but differ from the other; 2. German dormice take less time to reach adult size; 3. HBL reaches adult size quicker than W.

Differences related to time of birth and sex

Until now we have considered average values for our population, however as in the SW Iberia garden dormice has two distinct annual breeding periods (spring and autumn, Moreno 1984) a difference in growth-patterns between these two periods could be expected. Figure 2 shows some differences in weight increase between the young born in the first reproductive period (spring) and those born in the second (autumn). The growth of the spring-born youngs is relatively linear until they are 75–90 days old (when average weight is nearly 60 g and 60 % of the definitive value). The slope of the growth curve in the autumn-born youngs is smaller, linear until day 90 (when average weight of youngs 75–90 days old is 46 g and 49 % of the definitive value) decreasing by this time and returning to its former slope between day 150 and 180.

Although, the proportion of growth reached by spring-born youngs is relatively high, it does not approach that reached by young german dormice at same age (nearly 75 %).

No significant differences in growth rates were found between SW Iberian young males and females. This result was expected given the absence of sexual dimorphism in *Eliomys quercinus*.

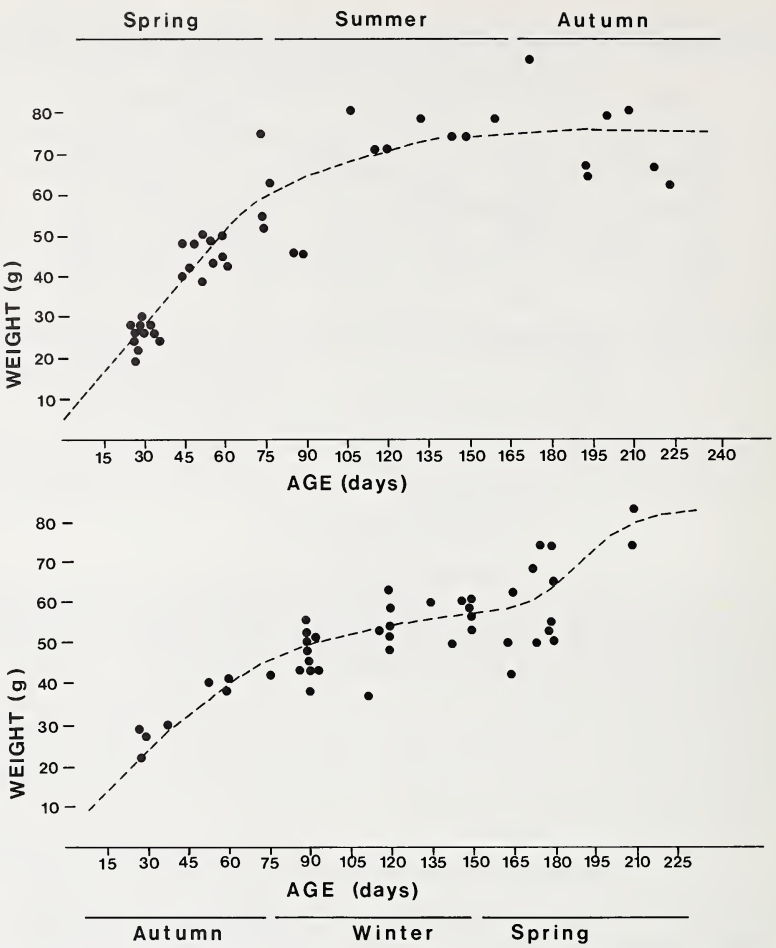

Fig. 2. Changes in weight of SW Iberian young garden dormice, *Eliomys quercinus lusitanicus,* (captured alive in the field) from their first capture, for dormice born in spring (top) and autumn (bottom). Lines were fitted by eye. Data coming from capture-recapture for 3 years pooled

Discussion

The results of this study reveal that during lactation and the onset of independent life, garden dormice from the SW of the Iberian Peninsula follow a growth pattern similar to that of dormice from Germany and Central Spain. The period of development of the SW Iberian subspecies, however, lasts longer, which may account for its larger size.

The relative growth rates of the El Pardo and SW Iberian specimens are similar at the same age, although the animals from Central Spain are smaller. This trend can be observed both in the development of the physiognomical characters before weaning as in the increase in weight and body measurements.

However, the relative growth rates of the german specimens are greater than those of the *lusitanicus* spanish ones. This difference is not only due to the influence of the *lusitanicus* autumn-born growth rates on the whole of the SW Iberian sample, as important

differences still appear when the growth of young spring-born is compared with that of the young german specimens.

Eisenberg (1981) has claimed that large-sized mammals need more time to reach adult size than smaller ones. According to this, the larger size of SW Iberian dormice could be the result of a longer growing period.

In fact this seems to be the case because the mildness of the winter in the study area allows the garden dormice to spend only a very short time in hibernation, and therefore also a very short time accumulating fat reserves to face hibernation energetic expenditures. In this way, the time spent by German dormice accumulating reserves and hibernating could be used by SW Iberian dormice to grow.

Different environmental conditions during the development seem to cause differences in growth patterns between spring and autumn-born youngs. The latter slowdown their growth during the winter, when they are 75–90 days old, and environmental conditions become adverse. 70 to 75 days later, at the beginning of the spring, they recover their initial growth rate.

A close relationship between environmental conditions and adult body size in garden dormice could also explain why *Eliomys quercinus* does not follow Bergman's rule in continental Europe, where average adult size decreases with latitude (Moreno in press).

However, this idea cannot be generalized, as north African garden dormice, genetically different from European ones (Delibes et al. 1980) are also of smaller size than the Spanish subspecies (Moreno and Delibes, 1981) although in theory the latitude allows a longer period of activity.

Clearly, ecological and genetical factors seem to be combined to determine the adult size of the different populations of dormice, and populations do not conform to simple zoogeographical rules.

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Zusammenfassung

Das Wachstum von südwestspanischen Gartenschläfern (Eliomys quercinus Linnaeus, 1766)

Das Wachstum südwestspanischer Gartenschläfer *(Eliomys quercinus lusitanicus)* wurde im Vergleich zu solchen aus Mittelspanien (El Pardo) und Deutschland untersucht. Zugrunde lagen Maße und Gewichte von 8 Nestlingen aus Gefangenschaft, 57 markierten und wiederholt gefangenen Jungtieren aus dem Freiland und 23 Jungtieren aus wissenschaftlichen Sammlungen. Die großen Gartenschläfer aus SW-Spanien und die kleineren aus Mittelspanien wachsen in gleichem Tempo aber gemeinsam langsamer als solche aus Deutschland, die etwa so groß werden wie die aus Mittelspanien.

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